Effect of Atmosphere, Surface, and Ocean Parameterizations on Ocean Model Performance

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LONG-TERM GOALS

The goal of this project is to quantify the effect of atmospheric forcing on a mesoscale ocean model. This goal is to be accomplished by first generating atmospheric forcing fields for extended periods and applying these to an ocean model, and then applying modified atmospheric forcing fields to the ocean model on subsequent runs. The atmospheric forcing fields will be modified in a variety of ways, to include different grid spacings and different/modified surface and boundary layer parameterizations.

OBJECTIVES

The objectives of this project are to (a) provide high-resolution atmospheric modeling support for ocean modeling, and (b) test the effect of the grid spacing of atmospheric models and new atmospheric surface and boundary layer formulations on ocean forecasts.

APPROACH

Our approach is to apply the existing atmospheric and ocean data assimilation and modeling infrastructure within the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS®1; Hodur 1997) to study the effects of atmospheric forcing on ocean forecasts. COAMPS is made up of the 3-dimensional NRL Atmospheric Variational Data Assimilation System (NAVDAS) for constructing atmospheric analyses; the NRL Coupled Ocean Data Assimilation (NCODA) analysis system for constructing ocean analyses; a nested, nonhydrostatic model for the atmosphere; and the NRL Coastal Ocean Model (NCOM). A general flux coupler allows one-way and two-way coupling of the COAMPS and NCOM models. COAMPS has been successfully applied to many atmospheric and ocean phenomena in many parts of the world. In this project, we use the atmospheric components of COAMPS for the support of real-time field experiments (e.g., the Adaptive Sampling and Prediction experiment, or ASAP) that are part of the Assessing the Effectiveness of Submesoscale Ocean Parameterizations (AESOP) project, and we will collaborate with others in this project for studies of atmospheric and ocean processes, and for model validation. We will generate real-time and historical datasets of high-resolution atmospheric forcing fields and provide these fields to ocean models for evaluation in ocean models. Additionally, we will generate modified atmospheric forcing fields using different grid spacings and different surface and boundary layer parameterizations to quantify the effect of these modifications on ocean forecasts.

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[1] COAMPS® is a registered trademark of the Naval Research Laboratory.

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WORK COMPLETED

In FY06, we continued running a COAMPS area using 4 nests (81, 27, 9, and 3 km) for the eastern Pacific for support of atmosphere/ocean modeling on the west coast of the U.S., in particular, in support of the ASAP project in Monterey Bay. 48-hour forecasts have been, and are continuing to be generated twice-daily in real-time (0000 and 1200 UTC), with the fields necessary for ocean model forcing transferred in real-time to a ftp server. In addition, the Fleet Numerical Meteorology and Oceanography Center (FNMOC) is using the 3 km COAMPS fields to drive the wave model, WaveWatch III, over the eastern Pacific and displaying these products on the web.

RESULTS

Support of the Autonomous Ocean Sampling Network-II (AOSN-II) field experiment in 2003, and ASAP in 2006, have led to significant findings in this project that are now being documented for publication. The support of these field experiments has shown that the generation of multiple-nest, high-resolution fields from COAMPS for forcing ocean models has led to significant improvements in air-ocean coupling. Strong gradients of temperature, wind, and wind stress are frequently found to occur along the west coast of the U.S. COAMPS solutions show relatively weak gradients with grid spacings of 27 km or higher, with successively stronger, and more realistic gradients found as the grid spacing decreases. The use of atmospheric forcing fields using different grid spacings results in significantly different ocean responses. With the relatively coarse resolution grids, the coastal jet is necessarily displaced several grid points off the coast, further from the coast than it is found in reality, although the maximum wind speed is typically forecast quite well. As the grid spacing is decreased, the position of the coastal jet is more properly represented closer to the coast. The impact of this is that the wind stress curl along the coast is found to be represented much better with a 3 km grid than it is with a 9 km (or coarser) grid. The erroneous wind stress curl in the coarser grids leads to significant errors in ocean model predictions of upwelling at the coast, while the upwelling forecasts are improved greatly with the use of atmospheric grids that use 3 km grid spacings. Some results from this work can be found at: http://www.nrlmry.navy.mil/coamps-web/web/mbay.

IMPACT/APPLICATIONS

The development of a fully-coupled mesoscale atmosphere-ocean data assimilation and prediction system (COAMPS) is considered to be the cornerstone for our studies of air-ocean research and for mesoscale predictions of the atmosphere and ocean for the Navy. The generation of COAMPS atmospheric forecast fields for forcing ocean models within this project are already having a significant impact in the studies of air-ocean coupling. These fields, with high-frequency time and space variations, are revealing the importance of mesoscale variations in the atmosphere on the ocean circulation and thermodynamic structure. As our ability to perform two-way coupled forecasts with increasingly higher horizontal resolution and improved physical parameterizations grows and matures in this project and other related projects, Navy forecasters will benefit from significant improvements in forecast skill for both the atmosphere and the ocean.

TRANSITIONS

The fully-coupled application of COAMPS will transition to 6.4 projects within PE 0603207N (SPAWAR, PMW-180) that focus on the transition COAMPS to FNMOC and the transition of the ocean data assimilation system for COAMPS.

RELATED PROJECTS

COAMPS will be used in related 6.1 projects within PE 0601153N that include studies of air-ocean coupling and boundary layer studies, and in related 6.2 projects within PE 0602435N that focus on the development of the atmospheric components (QC, analysis, initialization, and forecast model) of COAMPS. The fields from our atmospheric forecasts over the eastern Pacific will be used by scientists at NRL SSC and at the Naval Postgraduate School within their joint National Oceanographic Partnership Program (NOPP), to study air-ocean coupling processes on the west coast of the United States, as well as with other national and international collaborators.

REFERENCES

Hodur, R. M., 1997: The Naval Research Laboratory's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). *Mon. Wea. Rev.*, **125**, 1414-1430.

PUBLICATIONS

None.